

# *Blood and Plant Residues on Hawaiian Stone Tools from Two Archaeological Sites in Upland Kāneʻohe, Koʻolau Poko District, Oʻahu Island*



JANE ALLEN, MARGARET E. NEWMAN, MARY RIFORD,  
AND GAVIN H. ARCHER

ARCHAEOLOGICAL SITES in upland Kāneʻohe, windward Oʻahu, have produced evidence for terraced Hawaiian pondfield agriculture in valleys as early as A.D. 500 (Allen et al. 1987). Pit features and artifact deposits occupy ridges throughout the area, often lying buried more than 50 cms below surface (cmbs) (Williams 1991). Because most of the buried deposits lack clear evidence for site function or associations, interpretation has often proven difficult.

A pilot residue analysis of 20 basalt and volcanic glass (basaltic glass and trachyte) artifacts submitted from these and other sites on Oʻahu and Hawaiʻi islands in an attempt to clarify site use has produced the first five successful archaeological identifications reported for the archipelago. In spite of the fact that only ten antisera representing pre-Contact (pre-A.D. 1778) taxa were available for this study (Table 1), the results have changed functional interpretations of the Kāneʻohe sites. Fourteen additional antisera representing important economic taxa are now ready for use (Table 1).

This article provides background information regarding previous analyses of tool functions in Hawaiʻi, introduces the Kāneʻohe sites and the procedures used, summarizes traditional uses of the materials identified, and suggests directions for future research.

Identification of animal and plant residues is expected to make it possible to identify the precise materials that were traditionally scraped, chopped, stripped, or otherwise processed at Hawaiian sites. Beyond functional interpretation of individual artifacts, features, and sites, the technique can help to distinguish intersite

Jane Allen is a senior archaeologist with Ogden Environmental and Energy Services, Honolulu, Hawaiʻi.

Margaret E. Newman is at the Department of Archaeology, University of Calgary, Calgary, Alberta, Canada.

Mary Riford is at the Department of Anthropology, Bernice P. Bishop Museum, Honolulu, Hawaiʻi.

Gavin H. Archer is a graduate student in the Department of Anthropology, University of Arizona, Tucson.

TABLE 1. ANTISERA USED IN ANALYSES

AVAILABLE FOR THIS STUDY		PLANT ANTISERA PREPARED SINCE THIS STUDY	
ANTISERUM	SOURCE	ANTISERUM	SOURCE
Animal			
Anti-chicken	Organon/Teknika	Anti- <i>'awa</i> , kava	<i>Piper methysticum</i>
Anti-dog	Organon/Teknika	Anti- <i>hala</i> , pandanus	<i>Pandanus tectorius</i>
Anti-duck	Nordic Immunological	Anti- <i>hapu'u</i> , tree fern	<i>Cibotium</i> sp.
Anti-human	Organon/Teknika	Anti- <i>hau</i>	<i>Hibiscus tiliaceus</i>
Anti-mouse	Organon/Teknika	Anti- <i>kalo</i> , taro	<i>Colocasia esculenta</i>
Anti-pig	Organon/Teknika	Anti- <i>kī</i> , ti	<i>Cordyline fruticosa</i>
Anti-rat	Organon/Teknika	Anti- <i>koa</i>	<i>Acacia koa</i>
Anti-shark	Dr. J. Lowenstein	Anti- <i>kukui</i> , candlenut	<i>Aleurites moluccana</i>
Anti-sturgeon	Dr. J. Lowenstein	Anti- <i>loulou</i>	<i>Pritchardia</i> sp.
Plant			
Anti-fern ( <i>Polypodiaceae</i> )	University of Calgary	Anti- <i>noni</i>	<i>Morinda citrifolia</i>
		Anti- <i>'ohe</i>	<i>Schizostachyum glaucifolium</i>
		anti- <i>'ōhi'a 'ai</i> , moun- tain apple	<i>Syzygium malaccense</i>
		Anti- <i>'ōhi'a lehua</i>	<i>Metrosideros polymorpha</i>
		anti- <i>'ulu</i> , breadfruit	<i>Artocarpus altilis</i>

associations and may lead to better explication of past resource procurement routes and networks.

The current results include identifications of pig, dog, and fern residues (Newman 1992) on artifacts from Bishop Museum Sites 50-Oa-G5-97 and 50-Oa-G5-152 ("50-Oa-" hereafter omitted throughout this article), two ridge sites in Kāne'ōhe, O'ahu (Fig. 1), each incorporating stratified lithic concentrations and occupied between approximately A.D. 1600 and 1800.

#### PROBLEMS AFFECTING INTERPRETATION OF SITE FUNCTION AND TOOL USE IN HAWAII

Most Hawaiian structural elements that are sufficiently indestructible for archaeologists to find hundreds of years after abandonment are not discussed in the historical literature. While Malo (1951) and others describe timbers used in house construction, only a small number of accounts (e.g., Bird 1974: 152, 162; Handy and Handy 1972: 291, 293; Tī 1959) mention the rock features that characterize most sites (e.g., McAllister 1933).

Sites are generally interpreted, at least in part, on the basis of their artifactual assemblages. In Hawai'i, lithic artifact assemblages include both formal basalt tools (e.g., adzes, pounders), as a rule flaked and/or ground (very rare pecked examples are known), and unmodified basalt and volcanic glass flakes and angular fragments (the latter demonstrating no clear signs of flaking). Although certain formal tools are discussed in the historical literature in terms of uses, few are recovered, and, as Kirch (1985: 183) points out, even formal tools can rarely be defined in terms of specific uses. Adzes, for example, are believed to have been used in both canoe construction and field clearing. Flaked tools such as scrapers may have served many purposes. As will be discussed, the present study identified

substances adhering to the blade ends of two adzes (one a fragment) and the cutting edges of flakes apparently used as scrapers.

The vast majority of the artifacts found at Hawaiian sites are relatively unshaped flakes and angular fragments, whose sheer numbers often make full analysis (with microscopy) impractical. Flakes and fragments are also often omitted from discussions of Pacific assemblages because they are difficult to fit into traditional tool typologies, which emphasize formal types. In the absence of residue analysis, many flakes and fragments lacking macroscopic signs of edge damage (signs of possible use) have been reported in the past simply as "debitage" (i.e., waste, debris: Schick and Toth 1993:99) or uncertainly as either tools or waste (e.g., Allen et al. 1987:156–159; Athens and Kaschko 1989:75; Clark 1983:84; Kirch 1979:163, 169, 1989:120–122). Even where flakes exhibit clear signs of retouch and/or edge damage (and thus were used as tools before discard), the substances processed have eluded detection. The results reported here include the identification of residues adhering to the altered edges of three flakes.

The historical literature is occasionally helpful regarding flakes and fragments (and whole stones). Malo (1951:19) mentions the use of coral, pumice, and other stones to smoothe and polish canoes and wooden dishes. Handy and Handy (1972:176, 215) mention the use of stone blades to cut coconut shells for cups and use of beach stones and (undescribed) scrapers to clean gourds. Hard wood or stone was used to impress decorations on calabashes (Ellis 1853:4:373). Sharp stones were used as paper mulberry (*wauke*, *Broussonetia papyrifera*) cutters and to hew housing timbers (Fornander 1916–1920:638, 656). "Stone knives" were used to kill human sacrificial victims at *heiau* (traditional Hawaiian temples; Bille 1851:87). Flakes and split stones with sharp edges were used as kitchen knives (for example, on pig and dog meat); vesicular basalt or lava was used to scrape singed hair off pigs before cooking (Buck 1957:23, 26).

Other suggested uses for stone tools (including utilized flakes) in Hawai'i and the Pacific include: incising, gouging, and perforating; manufacturing bone fish hooks; processing fish and whale (in New Zealand) meat; tree felling; pandanus (*hala*, *Pandanus tectorius*) scraping and stripping; preparing taro (*kalo*, *Colocasia esculenta*) corms and yam (*uhi*, *Dioscorea alata*) tubers; woodworking; fire making; grubbing; ditch digging; and combinations of these (Allen 1986:152; Barrera and Kirch 1973:185–186; Cordy 1975:60, 63; Glover and Ellen 1975:59; Jacomb 1990:164; Kirch 1975:43, 1979:169, 1985:195; Reeve 1983:230–231; Richards 1990; Rosendahl 1972; Schilt ed. 1984:244; Walls 1991).

Several Hawaiian studies have analyzed edge wear and the possible uses to which flakes of materials including volcanic glass may have been put (e.g., Barrera and Kirch 1973; Morgenstein 1990; Morgenstein and Riley 1975). Others (e.g., Allen-Wheeler 1981; Allen et al. 1987; Athens 1983; Clark 1979; Clark and Riford 1986; Cleghorn 1974:46 and 1975: Appendix B; Kirch 1975:42–43, 1979:168–170; Riford 1994; Rosendahl et al. 1976; Schousboe et al. 1983) have analyzed flake size, lithic material, and/or morphology (e.g., presence of diagnostic signs of lithic reduction, edge modification, or remnant adze polish) to identify function. To date, none of these studies has been able to identify specific artifact function. Residue analysis can test the hypotheses generated by these and other earlier studies. In conjunction with edge-wear studies, the technique offers promise for accurate functional interpretation of stone tools (e.g., Fullagar 1988, 1989).

## RESIDUE ANALYSIS: BACKGROUND

Studies conducted since the 1970s have demonstrated that lithic artifacts often retain traces of organic residues resulting from their original use (Briuer 1976; Broderick 1979; Downs 1985; Gurfinkel and Franklin 1988; Hyland et al. 1990; Kooyman et al. 1992; Loy 1983, 1987; Loy et al. 1990, 1992; Loy and Wood 1989; Morgan et al. 1992; Newman 1990; Newman and Julig 1989; Shafer and Holloway 1979; Smith and Wilson 1992; Yohe et al. 1991). Methods used to detect and/or identify plant and animal residues recovered from artifacts, generally either ground or flaked stone tools or pottery, include microscopic, chemical, and immunological analyses. Microscopic studies include both analyses of edge damage on stone tools and studies designed to identify residues including erythrocytes, hemoglobin crystals, starch grains, opal phytoliths, and other mineral constituents (e.g., Anderson 1980; Bahn 1987; Hall et al. 1989; Kamminga 1979; Loy 1983). Despite skepticism regarding certain results (e.g., Smith and Wilson 1992), microscopy remains a valuable tool, especially when used in conjunction with other methods that produce quantifiable and replicable results (e.g., Fredericksen 1985; Fullagar 1988, 1989; Loy 1987; Newman 1992; Newman and Julig 1989; Newman et al. 1993; Yohe et al. 1991).

Chemical assessments range from in-field tests through quantitative laboratory analyses involving spectroscopy and chromatography. A variety of immunological tests have been used, including immunoabsorbent assay (ELISA), radioimmunoassay (RIA), and cross-over immunoelectrophoresis (CIEP) (e.g., Beck et al. 1989; Gurfinkel and Franklin 1988; Hill 1988; Hill et al. 1985; Oudemans and Boon 1991; Robinson et al. 1987).

The application of immunological and chemical methods to the analysis of residues on archaeological materials offers a new and exciting means by which we can extend our knowledge of past cultures. Recent studies show that protein residues from animals and plants on which the artifacts were used can now be identified to at least the family taxonomic level (Heron et al. 1991; Hyland et al. 1990; Kooyman et al. 1992; Lowenstein 1981, 1985; Newman 1990; Newman and Julig 1989; Newman et al. 1993; Yohe et al. 1991). Information gained from these analyses can be used in the reconstruction of subsistence patterns and possibly in identifying task-specific artifacts.

Although various immunological methods have been used, the basis of all is the antigen-antibody reaction first observed in the classic precipitin test in the late nineteenth century. Following its discovery, the test quickly achieved integrity in the fields of clinical and forensic medicine and has been used extensively in medicolegal work since the beginning of this century (Culliford 1964; Gaensslen 1983). Although the successful identification of protein residues is dependent on their condition, forensic studies have demonstrated that proteins are extremely robust molecules and can withstand harsh treatment while still retaining their antigenicity and biological activity (e.g., Arquembourg 1975; Haber 1964; Gaensslen 1983; Lee and DeForest 1976; Macey 1979; Sensabaugh et al. 1971). The fact that valid results from the analysis of old and severely denatured proteins are obtained in forensic medicine is of special relevance to archaeology, where old and denatured proteins are the norm. The sensitivity and specificity of precipitin



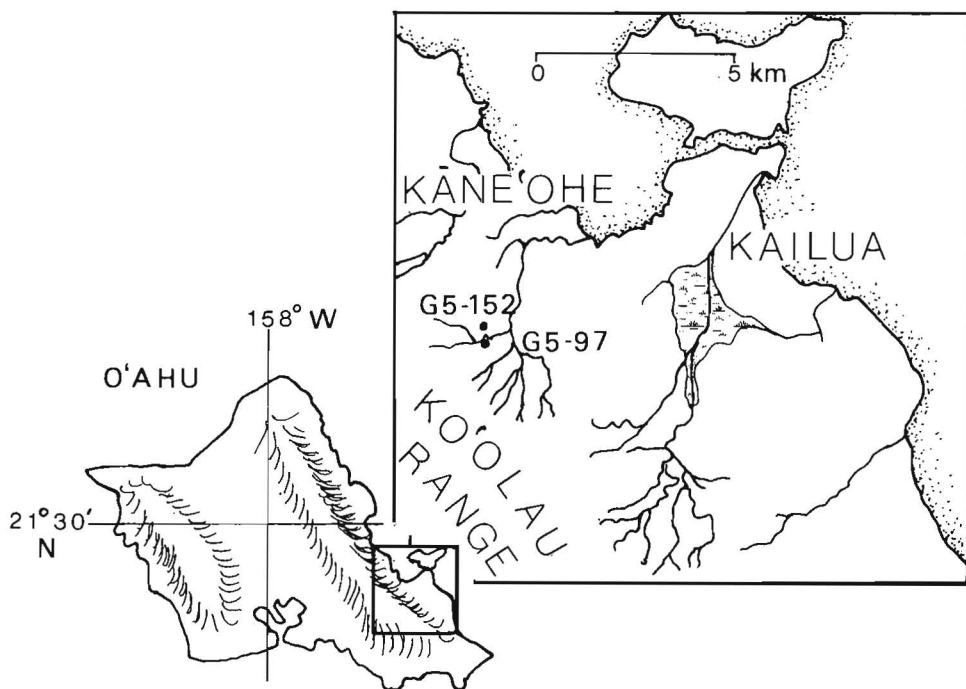


Fig. 1. Locations, Sites 50-Oa-G5-97 and 50-Oa-G5-152, Kāne'ohe, Ko'olau Poko District, O'ahu, Hawai'i.

reactions makes them an extremely effective method for the detection of trace amounts of protein (Kabat and Meyer 1967:22).

#### THE SITES AND ARTIFACTS

Site G5-97, located on a narrow colluvial ridge that originates in the Ko'olau Range (Fig. 1), incorporates a post-Contact burial site (Allen et al. 1987) and the earlier lithic concentrations (Archer 1992) that produced the artifacts reported here. Two main cultural layers at Site G5-97 produced 132 basalt and 1246 volcanic glass flakes and fragments (field counts). Four volcanic glass flakes and one angular fragment were submitted for residue analysis. As will be discussed, one of the flakes, the only piece displaying edge alteration, produced positive results (Tables 2, 3).

Site G5-152, on another colluvial ridge, incorporates surface rock features and 39 buried features, including *imu* (earth ovens), fire- and refuse pits, charcoal concentrations, and the two extensive lithic concentrations that produced the reported artifacts. Site G5-152 produced 497 basalt artifacts, including adzes, flakes, and fragments, and 1087 volcanic glass flakes and fragments (field counts) in three layers. The six basalt artifacts selected for analysis include an adze and an adze fragment showing no recognizable edge alteration, and four edge-altered pieces: an adze flake, two flakes, and one angular fragment. Three volcanic

TABLE 2. SUMMARY: DESCRIPTIONS AND CONTEXTS, ARTIFACTS WITH IDENTIFIED RESIDUES

ARTIFACT NUMBER (50-Oa-)	SIZE <sup>a</sup> (cm)	DESCRIPTION	CONTEXT/UNIT SIZE (m <sup>2</sup> )	ARTIFACT COUNT IN LAYER IN UNIT
G5-97-55	1.1/0.9/ 0.4	Volcanic glass flake	Unit 48: Layer IIa, 17 cmbs <sup>b</sup> /0.25	Layer IIa: 1 basalt, 34 volcanic glass
G5-152-23	2.5/2.0/ 0.7	Basalt adze fragment	Grid 1, Feature 13: Layer II/III (graded area)/ 444.0	Layer II/III: 22 ba- salt, 15 volcanic glass
G5-152-26	5.4/2.3/ 1.1	Basalt adze flake	Unit 7 : Layer II, 5 cmbs/1.0	Layer II: 8 basalt, 3 volcanic glass
G5-152-27	4.1/1.8/ 0.8	Basalt microadze	Unit 7: Layer II, 12 cmbs/1.0	Layer II: 8 basalt, 3 volcanic glass
G5-152-172	5.4/5.1/ 1.1	Basalt flake	Unit 8: Layer II, 12 cmbs/1.0	Layer II: 7 basalt, 2 volcanic glass

<sup>a</sup> Length/width/thickness.  
<sup>b</sup> Centimeters below surface.

TABLE 3. ARTIFACT SUMMARY: FUNCTIONAL INFORMATION AND RESIDUES IDENTIFIED

ARTIFACT NUMBER (50-Oa-)	DESCRIPTION	LOCATION OF AREA TESTED	MICROSCOPIC TRACES OF WEAR	RESIDUE IDENTIFIED
G5-97-55	Volcanic glass flake	Distal end	Flake scars	Dog
G5-152-23	Basalt adze fragment	Blade end	None	Pig
G5-152-26	Basalt adze flake	Distal end	Rounding	Dog
G5-152-27	Basalt microadze	Blade end	None	Fern
G5-152-172	Basalt flake	Both lateral edges	Rounding	Pig

glass flakes (one displaying edge alteration) and one angular fragment were also selected. The basalt adze, adze fragment, adze flake, and one of the edge-altered flakes were successful.

The main pre-Contact cultural layers at the two sites are Layers II and III. Site G5-152 Layer II produced the following conventional radiocarbon ages on wood charcoal processed at Beta Analytic, Inc., Miami, Florida: 110 ± 60 B.P., 160 ± 70 B.P., and 180 ± 60 B.P. (Bishop Museum HRC Nos. 1452, 1451, 1450; Beta Analytic Nos. B-55834, B-55833, B-55832). Layer III was dated to 310 ± 50 B.P. (HRC 1453, B-55835). Soils at both sites are acidic (pH 5.7, 5.8 in Layer II, Site G5-97) to strongly acidic Lolekaa silty clays (Foote et al. 1972: 83-84) formed on old, gravelly basaltic colluvium. Preservation of most free organics is poor. The residues identified on artifacts collected from these acidic soils are promising, in that they suggest that organic residues bound to tools may survive reasonably well in Hawai'i's lateritic soils.

The third Kāne'ohe site, Site G5-153, is another ridge site, located adjacent to Site G5-152. One volcanic glass flake from Site G5-153 and four from various sites in Kohala, Hawai'i Island, were analyzed, without success.

## ARTIFACT PROCESSING

Of the 20 pieces analyzed, the 16 pieces from the Kāne'ohe sites were left uncleaned. The four Hawai'i Island pieces had been cleaned previously. The pieces submitted were selected to crosscut artifact categories and lithic materials. All were examined microscopically at 10x magnification and were selected either for physical signs of use wear or for their association with activity areas. All artifacts were handled as little as possible, with clean forceps and/or gloves. Samples of associated soils were submitted with the Kāne'ohe artifacts for control purposes. The materials were stored in polyethylene bags and were wrapped in foam padding for shipment to the Laboratory of Archaeological Science, California State University, Bakersfield.

The method of analysis used is cross-over immunoelectrophoresis (CIEP), based on the work of Culliford (1964) with minor changes, following the methods of the Royal Canadian Mounted Police Serology Laboratory, Ottawa (Royal Canadian Mounted Police 1983), and the Centre of Forensic Sciences, Toronto. The test is extremely sensitive and can detect  $10^{-8}$ g of protein (Culliford 1964: 1092). The procedure is discussed fully in Newman and Julig (1989). As indicated, control soil samples from Sites G5-97 and G5-152 were also tested. As soil contaminants such as bacteria, tannic acid, and iron chlorates may result in nonspecific precipitation of antiserum, it is important that associated soils be analyzed (Gaensslen 1983).

Possible residues were removed from specified edges of the artifacts (Figs. 2-4, Table 3) by the use of a 5 percent ammonium hydroxide solution. This has been shown to be the most effective extractant for old and denatured bloodstains and does not interfere with subsequent testing (Dorrill and Whitehead 1979; Kind and Cleevely 1969). The artifacts were placed in shallow plastic dishes and 0.5 ml of the 5 percent ammonia solution applied with syringe and needle.

Initial disaggregation of residue was carried out by floating the plastic dish and its contents in an ultrasonic cleaning bath for two to three minutes. Extraction was continued by placing the boat and contents on a rotating mixer for thirty minutes. The resulting ammonia solution was removed with a pipette and placed in a numbered plastic vial and refrigerated prior to further testing. Approximately 1 ml of Tris buffer (pH 8.0) was added to the soil samples, mixed well, and allowed to extract for 24 hours at 4°C to prevent bacterial contamination. The resulting supernatant fluid was removed for testing.

Artifact and soil samples were first tested against pre-immune serum (i.e., serum from a nonimmunized animal) to determine if contaminants were present. A positive result against pre-immune serum could arise from nonspecific protein interaction not based on the immunological specificity of the antibody (i.e., nonspecific precipitation). No positive results were obtained. All artifact samples were then tested against the antisera shown in Table 1a. Duplicate testing was carried out on all positive reacting specimens.

Animal antisera obtained from commercial sources are developed specifically for forensic medicine and are thoroughly tested against other related and unrelated animal species. Additional testing against species not tested by the manufacturer is routinely carried out with each new lot of antisera to ensure that no cross-reactivity goes unrecognized. Where cross-reactions occur, these are noted on the

PLATFORM

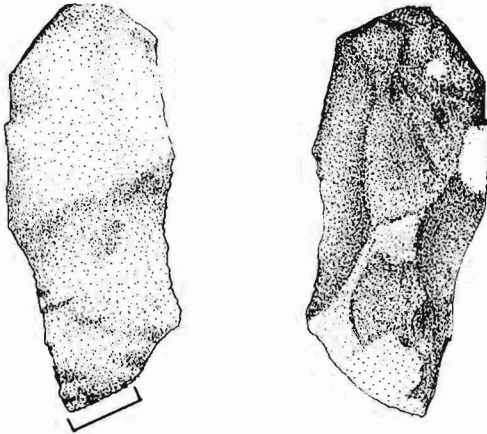


EDGE ALTERATION

Artifact 50-Oa-G5-97-55



PLATFORM



ROUNDING ON EDGE

Artifact 50-Oa-G5-152-26

Fig. 2. Artifacts 50-Oa-G5-97-55 (volcanic glass flake, tested in area of possible edge alteration) and 50-Oa-G5-152-26 (basalt flake, tested on rounded edge). Residues on both reacted to dog antiserum.

product sheets included with each new batch of antisera (e.g., positive results to mouse antiserum also occur with rats). The antisera used are polyclonal: that is, they will recognize epitopes shared by closely related species. For example, anti-deer will give positive results with members of the Cervidae family, including deer, moose, elk, and caribou, as well as with pronghorn in the Antilocapridae family.

RESULTS AND DISCUSSION

Five of the 20 artifacts yielded positive results, with the other 15 producing no reactions to the antisera that were available when the study began.

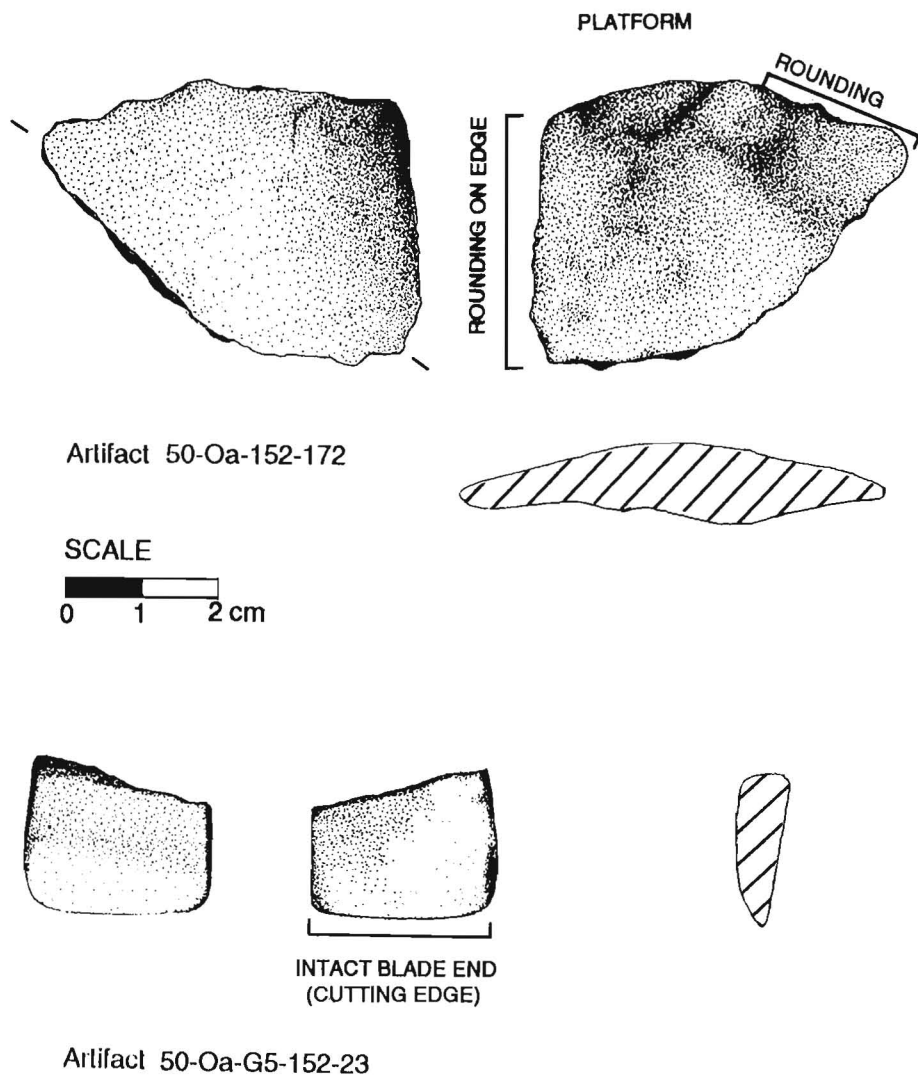
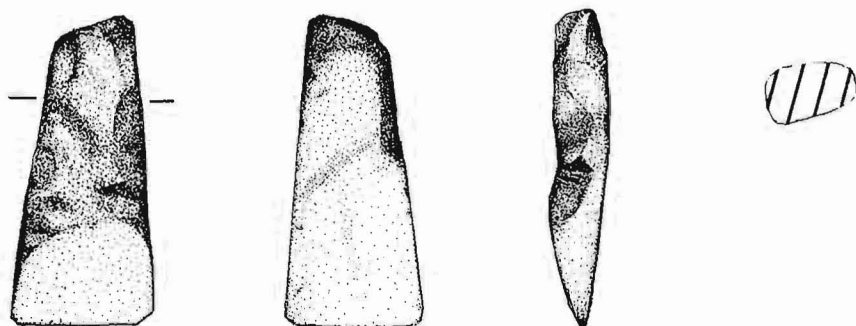


Fig. 3. Artifacts 50-Oa-G5-152-172 (basalt flake, tested on rounded edge) and 50-Oa-G5-152-23 (basalt adze fragment, tested on cutting edge). Residues on both reacted to pig antiserum.

### *Negative Results*

The 15 pieces that did not react include four volcanic glass pieces (none displaying edge alteration) from Site G5-97; two basalt pieces (with edge alteration) and four volcanic glass pieces (including an edge-altered flake) from Site G5-152; the glass flake (no edge alteration) from Site G5-153; and the four previously cleaned glass flakes (all edge-altered) from Hawai'i Island sites. The absence of identifiable proteins on these 15 artifacts may be due to poor preservation of protein or to the fact that the artifacts had been used on taxa other than those covered by the available antisera. It is also possible that the artifacts had not been used.



CUTTING EDGE

Artifact 50-Oa-G5-152-27

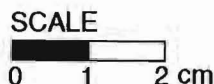


Fig. 4. Artifact 50-Oa-G5-152-27 (basalt microadze, tested on cutting edge). Residue on this artifact reacted to common fern antiserum.

### Positive Results

The five successful artifacts include the volcanic glass flake from Site G5-97 and four basalt artifacts from Site G5-152, including the adze fragment, the microadze, and two flakes.

*Edge Wear* — Two of the successful artifacts, G5-97-55 and G5-152-172, had been identified prior to microscopy as debitage. Microscopy under incident (reflected) light revealed edge alteration on three of the five successful pieces, including these two flakes. Edge alteration included scarring and rounding. In all cases, the alteration indicated use in the transverse direction (across the edge). The captions to Figures 2 through 4, which illustrate the five successful pieces, indicate the surfaces affected by edge alteration and tested for residues.

Artifact G5-97-55, the volcanic glass flake and the smallest piece submitted, showed small flake scars on the distal end, suggesting use on a resistant material. Artifact G5-152-26, a basalt flake, exhibited rounding of the distal end, as though it had been used to scrape soft or smooth material. G5-152-172, another basalt flake, displayed rounding on lateral edges on both sides of the platform, but none on the distal end. It was apparently used more than once on a soft or smooth material.

Artifacts G5-152-23 and G5-152-27, the adze and adze fragment, exhibited no evident flaking or use striations on microscopic examination. Polishing of the blade ends might make rounding difficult to recognize. An unidentified, viscous substance was noted adhering to the blade end of Artifact G5-152-23.

*Residues* — Artifacts G5-97-55 (volcanic glass flake) and G5-152-26 (basalt flake) produced positive reactions to dog antiserum. Although any member of Family Canidae could be represented, only *Canis familiaris* (fido) was present in pre-Contact Hawai'i. Cross-reactions with other families are not reported.

Artifacts G5-152-23 (adze fragment) and G5-152-172 (flake) reacted to pig (Family Suidae) antiserum. The viscous substance found on the former during microscopy is probably pig flesh or blood. The domestic pig (*pua'a*, *Sus scrofa*) was the only member of Family Suidae present in pre-Contact Hawai'i. Cross-reactions with other families do not generally occur.

Artifact G5-152-27, the microadze, reacted positively to fern antiserum, which was raised against bracken fern (*Pteridium* sp.) and will elicit positive reactions from all members of the common fern family (Family Polypodiaceae). (Current ground cover at the site does not include ferns.)

#### *Documented Uses of Materials Present at the Sites*

Domesticated pig and dog (and jungle fowl) were brought to Hawai'i by the first Polynesian colonists and raised primarily for food. Pigs prepared as food were cleaned, their hairs singed, and cooked in an *imu*. Under the *kapu* (taboo) system, neither women nor small boys were ordinarily allowed to eat pork (Malo 1951:29; Pukui et al. 1972). Pigs were frequently sacrificed at *heiau*. Dogs were a favorite dish of the *ali'i* (elite classes). Young dogs were broiled; older dogs were customarily cooked in an *imu*, sometimes cut up and placed in ti (*kī*, *Cordyline fruticosa*) leaf bundles (Titcomb 1969:2, 4, 10-12). Dogs were also regarded as pets and were buried as companions (Bird 1974:152; Titcomb 1969:10). Dog burials are known for sites, including Kāne'ohe Site G5-95, between the sites discussed here. Less often sacrificed than pigs, dogs were nonetheless offered to female gods and gods who lived in the water, and during healing ceremonies (Titcomb 1969:18-19).

Members of the common fern family present in pre-Contact Hawai'i include the following: sword ferns (including *kupukupu* and *ni'ani'au*, *Nephrolepis* spp.), used to decorate pandanus mats; lace fern (*pala'ā* or *palapala'ā*, *Sphenomeris chusana*), which produces a brown dye; oak ferns (*kikawaiō*, *Dryopteris cyatheoides*; *hō'i'o kula*, *D. sandwicensis*), used as food and medicine; bird's nest fern (*'ēkaha*, *Asplenium nidus*), used to decorate mats and cover tree stumps; paco, including an endemic species (*hō'i'o*, *Athyrium arnottii*), whose young fronds were eaten; and the maile-scented fern (*laua'e*, *Microsorium scolopendria*), used ornamentally and as perfume (Handy and Handy 1972; Neal 1965:12-28). Tree ferns are more likely than ground ferns to have required cutting with an adze; two tree ferns used traditionally belong to Polypodiaceae: *'ama'u* (*Sadleria cyatheoides*) and *'ākōlea* (*Athyrium microphyllum*). *'Ama'u* was used for housing material (Fornander 1916-1920:654; Kamakau 1976:103; Neal 1965:22-23), mulch, and other purposes (Handy and Handy 1972:234; Pukui and Elbert 1986). *'Ākōlea* was often cleared from *'ōhia* groves before taro planting (Fornander 1916-1920:686). *'Ōhi'a lehua* (*Metrosideros polymorpha*) is common above Site G5-152; taro was once grown extensively nearby (Allen 1991, 1992; Allen et al. 1987).

#### *Residues as Potential Indicators of Tool Use*

As mentioned, lithic analysis is often prioritized in favor of studying formal tools rather than investing the time necessary to analyze hundreds or thousands of flakes and fragments. Residues were identified during this study on two flakes assessed



initially as debitage. Adze fragments, like flakes, are also often assumed to represent debitage. The current microscopic and CIEP results indicate that at least some pieces in both categories were used; even probable debitage should be sampled for microscopy and residue analysis.

Small sizing affects especially Hawaiian volcanic glass pieces (e.g., Artifact G5-97-55), which frequently measure less than 0.5 cm in length or diameter, reflecting the small sizes of most available source dikes. The possible use of small, razor-sharp flakes as tools suggests that they may have been hafted to handles. Gums and resins used in Hawai'i (for other purposes) include candlenut (*kukui*, *Aleurites moluccana*) gum, breadfruit ('ulu, *Artocarpus altilis*) latex, and the saps of a native lobelia ('ōhākēpau, *Clermontia hawaiiensis*) and an amaranth (*pāpala*, *Charpentiera* sp.) (Handy and Handy 1972:154, 231, 238, 626-627; Neal 1965:303, 816; Wagner et al. 1990:189-192, 430). Hafting gums will appear on proximal ends.

Even the absence of diagnostic flaking traits does not necessarily identify a stone item as waste. Sharp, angular fragments could be used for cutting and scraping and need to be tested. Lack of obvious edge damage may also fail as a predictor of use or nonuse. Although animal bone and skin might be expected to scar a tool, flesh and many vegetable substances might not. Again, the adze with fern residue analyzed here displayed no (recognized) postmanufacture edge damage. Pieces used once and discarded may produce residues when tested against antisera for taro, ti, breadfruit, and other cultigens.

#### *Residues and Site Function: How Specialized Are Specialized Sites?*

An important early study (Barrera and Kirch 1973:186) referred to volcanic glass flakes as a sort of Hawaiian "pocket knife": these tools, and the slightly less numerous basalt flakes, are nearly ubiquitous at sites of many types. The current identification of dog and pig residues on three flakes broadens the range of known materials processed by flakes at lithic workshops and suggests that flakes indeed served as multipurpose tools even at specialized sites. Although tools produced in workshops are generally assumed to have been designed for use elsewhere, some Kāne'ohe tools were probably used on site for domestic or other purposes. Temporary habitation may be suggested by the preparation of pig and dog, presumably for cooking.

The fern identified for site G5-152 may have been cut on site or elsewhere. If it represents 'ama'u, the residue might possibly suggest construction of a shelter for temporary occupation. Reexamination of site records revealed, between the adze findspot and a posthole recognized in the field, three additional possible postholes. The shelter suggested would have been 1.5 m wide and 2.0 m long, with the adze locality, a lithic scatter, and firepits just outside the structure. Clearing of 'ākōlea for taro planting must also be considered a possible explanation for the fern residue in this agriculturally dominated area.

Although any interpretations coming out of this first small study must remain tentative, it appears likely that the Kāne'ohe workshops were involved in a broader range of activities than might be suggested by strictly technological analysis, or by the term "lithic workshop," and that domestic and specialized activities overlapped at specialized sites, as they did at more general, domestic sites in Hawai'i.

CONCLUSION: SOME IMPLICATIONS OF RESIDUE IDENTIFICATION  
FOR STUDIES OF CULTURE PROCESS IN HAWAII

Residue analysis will help to refine our interpretations of sites of many types, from house sites and workshops to agricultural fields and, importantly, sacred sites.

Sacred sites possess potential to inform not only regarding religious practices but past sociopolitical patterns. First, specific *heiau* functions need to be identified (e.g., Kolb 1991) and unusual material distributions explained (Allen et al. 1994; Riford 1994). Archaeological interpretations of possible *heiau* and other politically sensitive sites are increasingly, and understandably, being called into question by Hawaiians. Residue identification, which is nondestructive of artifacts, has the potential to identify the specific materials offered at a *heiau*, suggesting its function, for example, as an agricultural or fishing-oriented productivity *heiau*. Such identifications can greatly enhance the capability of archaeology to contribute accurate functional information toward site interpretation.

Questions are also being asked concerning the possible gender associations of sites of both religious and secular types. Residue analysis, in conjunction with ethnography, may suggest gender-related information. As mentioned, under *kapu*, women were not ordinarily permitted to eat pork: pig residues might possibly suggest male use of sites such as Site G5-152. Dogs were eaten by both sexes and were offered to female deities. The presence of dog blood on artifacts would not be inconsistent with female involvement at a site.

One important goal of Hawaiian archaeological research is to understand how land use and settlement patterns changed through time, and how these changes reflect socioeconomic and political transformations that culminated in the emergence of the pre-Contact Hawaiian state (or complex chiefdom, depending on the view of the individual researcher: e.g., Allen 1991; Cordy 1981; Earle 1978; Hommon 1976, 1986; Kirch 1984; Kolb 1991). In order to explain general patterns, it is first necessary to explain the local-level patterns out of which the larger systems developed. Residues can help to clarify resource procurement routes, exchange networks, and site use by members of particular social classes. Residues of forest products (e.g., forest birds, sandalwood) will, for example, presumably be found at coastal sites: such finds, especially if dateable (Loy et al. 1990), can help to clarify the development of both mountain-to-sea procurement networks and the land units that later emerged out of them. The presence of residues of valued forest items at such a site might suggest that an *ali'i* oversaw the procurement.

One of the first steps to be taken, as the data base grows, must be to try to correlate identified residues with specific technological and functional tool types. Along with organic materials, tools were used and left at sites of various types, were used by both men and women, and were made from rocks that were often transported over long distances, probably along exchange networks. Analyzing residues as well as the associated tool types should significantly increase our ability to explain functional variability and regularities at the artifact, feature, site, and intersite levels. The combined approaches, in conjunction with other analyses, can help to refine explanatory models for sociopolitical site associations, resource procurement routes, expanding economic networks, and the economic and sociopolitical activities that integrated communities within Hawaiian society.

## ACKNOWLEDGMENTS

The support and funding the project received from the Federal Highways Administration and the Hawaii State Department of Transportation are gratefully acknowledged. The research reported here was supervised by J. Allen while she was employed by Bishop Museum. Dr. Newman directed the residue analysis at the Laboratory of Archaeological Science, California State University, Bakersfield. Thanks to Bishop Museum for undertaking this pilot project, and to the staff of the Laboratory of Archaeological Science at California State University for their careful processing of the samples. Helen Leidemann and Dr. Barbara Dolan, who codirected the Kāne'ohe project with Mary Riford, and Supervisors Mary Clarke and Frank Thomas contributed skill and insights. Helen, Lynn Miller, and Heidi McMahon collected the successful artifacts. Angela Steiner-Horton, Collections Manager for Archaeology, coordinated post-field procedures, and, with the assistance of Leann Woodward McGerty and Charlie Ogata, collected and submitted the plants listed in Table 1b; Dr. Fiona Norris of the Bishop Museum Botany Department verified plant identifications. Hemantha Jayatilleke drafted the lithic illustrations, and Priscilla Billig, Sean Shiraishi, and Grace Valiente-Sacramento edited and produced both tables and text. Comments made by Richard Fullagar, Michael Graves, Helen Leidemann, and Dave Soldo on an earlier draft helped greatly. Finally, thanks to all the field and laboratory assistants for their careful collection and their willingness to try something new.

## REFERENCES CITED

- ALLEN, J.  
 1986 Phase I intensive survey and Phase II excavations at TMK 7-5-09:31, Kailua, Kona, Island of Hawai'i. Manuscript on file, Archives, Bishop Museum, Honolulu.  
 1991 The role of agriculture in the evolution of the pre-Contact Hawaiian state. *Asian Perspectives* 30: 117-132.  
 1992 Farming in Hawai'i from colonisation to Contact: Radiocarbon chronology and implications for cultural change. *New Zealand Journal of Archaeology* 14.
- ALLEN, J., M. RIFORD, T. M. BENNETT, G. M. MURAKAMI, AND M. KELLY  
 1987 *Five Upland 'Ili: Archaeological and Historical Investigations in the Kāne'ohe Interchange, Interstate Highway H-3, Island of O'ahu*. Department of Anthropology Report Series 87-1. Honolulu: Bishop Museum.
- ALLEN, J., M. RIFORD, G. M. MURAKAMI, AND L. SCOTT CUMMINGS  
 1994 *Kula and kahawai: Geoarchaeological and historical investigations in middle Maunawili Valley, Kailua, Ko'olau Poko, O'ahu*. Manuscript on file, Anthropology Department, Bishop Museum, Honolulu.
- ALLEN-WHEELER, J.  
 1981 Archaeological excavations in Kawainui Marsh, O'ahu. Manuscript on file, Archives, Bishop Museum, Honolulu.
- ANDERSON, P. C.  
 1980 A testimony of prehistoric tasks: Diagnostic residues on stone tool working edges. *World Archaeology* 12: 181-194.
- ARCHER, G.  
 1992 Recovering and interpreting spatial data: Methods for contract archaeology in Ko'olau Poko, O'ahu. Paper presented at the Fifth Annual Conference of the Society for Hawaiian Archaeology, Kaua'i, March 27-29.
- ARQUEMBOURG, P. C.  
 1975 *Immuno-electrophoresis: Theory, Methods, Identification, Interpretation*. Basel-Munich: S. Karger.
- ATHENS, J. S.  
 1983 Prehistoric pondfield agriculture in Hawai'i: Archaeological investigations at the Hanalei Wildlife Refuge, Kaua'i. Manuscript on file, Archives, Bishop Museum, Honolulu.

- ATHENS, J. S., AND M. W. KASCHKO  
1989 Prehistoric upland bird hunters: Archaeological inventory survey and testing for the MPRC Project Area and the Bobcat Trail Road, Pohakuloa Training Area, Island of Hawai'i. Manuscript on file, Hawai'i State Historic Preservation Division, Honolulu.
- BAHN, P. G.  
1987 Getting blood from stone tools. *Nature* 330:14.
- BARRERA, W. M., JR., AND P. V. KIRCH  
1973 Basaltic-glass artifacts from Hawaii: Their dating and prehistoric uses. *Journal of the Polynesian Society* 82:176-187.
- BECK, C. W., C. J. SMART, AND D. J. OSSENKOP  
1989 Residues and linings in ancient Mediterranean transport amphoras, in *Archaeological Chemistry IV*:369-380, ed. R. O. Allen. Advances in Chemistry Series 220. Washington, D.C.: American Chemical Society.
- BILLE, S.  
1851 Report on the corvette Galathea's circumnavigation, 1845, 1846, and 1847. Parts II and III. Report on file, Carter Collection, Bishop Museum Library, Honolulu.
- BIRD, I. L.  
1974 *Six Months in the Sandwich Islands*. Rutland, Vermont, and Tokyo, Japan: Charles E. Tuttle Co.
- BRIUER, F. L.  
1976 New clues to stone tool function: Plant and animal residues. *American Antiquity* 41:478-484.
- BRODERICK, M.  
1979 Ascending paper chromatographic technique in archaeology, in *Lithic Use-Wear Analysis*:375-383, ed. B. Hayden. New York: Academic Press.
- BUCK, P. H. [Te Rangi Hiroa]  
1957 *Arts and Crafts of Hawai'i*. Honolulu: Bishop Museum Press.
- CLARK, J. T.  
1983 Archaeological investigations in Section 1, in *Archaeological Investigations of the Mudlane-Waimea-Kawaihai Road Corridor, Island of Hawai'i*:61-137, ed. J. T. Clark and P. V. Kirch. Department of Anthropology Report Series 83-1. Honolulu: Bishop Museum.
- CLARK, S. D.  
1979 An analysis of Hawaiian basalt awls: A replication and use-wear experiment. Manuscript on file, Anthropology 381, University of Hawai'i, Honolulu.
- CLARK, S. D., AND M. RIFORD  
1986 Archaeological salvage excavations at Site 50-Oa-G5-101, Waikalua-Loko, Kāne'ohe, Ko'olau-poko, O'ahu Island, Hawai'i. Manuscript on file, Archives, Bishop Museum, Honolulu.
- CLEGHORN, P. L.  
1974 Survey and salvage excavations in specified areas of Wailea lands, Maui. Manuscript on file, Archives, Bishop Museum, Honolulu. Revised 1976.  
1975 Phase II, Part 2: Archaeological salvage operations at Site 50-Ma-B10-1, Wailea, Kihei, Maui. Manuscript on file, Archives, Bishop Museum, Honolulu.
- CORDY, R. H.  
1975 Hawaiian activity sets: Initial results of R-mode multivariate statistical analyses. *New Zealand Archaeological Association Newsletter* 18:59-75.  
1981 *A Study of Prehistoric Social Change: The Development of Complex Societies in the Hawaiian Islands*. New York: Academic Press.
- CULLIFORD, B. J.  
1964 Precipitin reactions in forensic problems. *Nature* 201:1092-1094.
- DORRILL, M., AND P. H. WHITEHEAD  
1979 The species identification of very old human bloodstains. *Forensic Science International* 13:111-116.
- DOWNES, E. F.  
1985 An approach to detecting and identifying blood residues on archaeological stone artifacts:

A feasibility study. Manuscript on file, Center for Materials Research in Archaeology and Ethnology, Massachusetts Institute of Technology, Cambridge.

EARLE, T. K.

- 1978 *Economic and Social Organization of a Complex Chiefdom: The Halelea District, Kaua'i, Hawai'i*. Anthropological Papers of the Museum of Anthropology 63. Ann Arbor, MI: University of Michigan.

ELLIS, W.

- 1853 *Polynesian Researches during a Residence of Nearly Eight Years in the Society and Sandwich Islands*. Vol. 4. London: Henry G. Bohn.

FOOTE, D. E., E. L. HILL, S. NAKAMURA, AND F. STEPHENS

- 1972 *Soil Survey of the Islands of Kauai, Oahu, Maui, Molokai, and Lanai, State of Hawaii*. U.S.D.A. Soil Conservation Service. Washington, D.C.: U.S. Government Printing Office.

FORNANDER, A.

- 1916– *Fornander Collection of Hawaiian Antiquities and Folk-Lore*, ed. T. G. Thrum. Memoirs of the Bernice Pauahi Bishop Museum, vols. 4–6. Honolulu: Bishop Museum.

FREDERICKSEN, C.

- 1985 The detection of blood on prehistoric flake tools. *New Zealand Archaeological Association Newsletter* 28: 155–164.

FULLAGAR, R.

- 1988 Recent developments in Australian use-wear and residue studies, in *Industries lithiques: Traceologie et technologie*: 133–145, ed. S. Beyries. Oxford: British Archaeological Reports International Series 411.
- 1989 The potential of lithic use-wear and residue studies for determining stone tool functions, in *A Crack in the Spine: Prehistory and Ecology of the Yimi-Yuat Valley, Papua New Guinea*: 209–223, ed. P. P. Gorecki and D. Gillieson. Townsville: James Cook University of North Queensland.

GAENSSLEN, R. E.

- 1983 *Sourcebook in Forensic Serology, Immunology, and Biochemistry*. Washington, D.C.: U.S. Department of Justice.

GLOVER, I. C., AND R. F. ELLEN

- 1975 Ethnographic and archaeological aspects of a flaked stone collection from Seram, Eastern Indonesia. *Asian Perspectives* 18: 51–60.

GURFINKEL, D. M., AND U. M. FRANKLIN

- 1988 A study of the feasibility of detecting blood residue on artifacts. *Journal of Archaeological Science* 15: 83–97.

HABER, E.

- 1964 Recovery of antigenic specificity after denaturation and complete reduction of disulfides in a papain fragment of antibody. *Proceedings of the National Academy of Sciences* 52: 1099–1106.

HALL, J., S. HIGGINS, AND R. FULLAGAR

- 1989 Plant residues on stone tools, in *Plants in Australian Archaeology*: 136–160, ed. W. Beck, A. Clarke, and L. Head. *Tempus* 1.

HANDY, E. S. C., AND E. GREEN HANDY

- 1972 *Native Planters in Old Hawaii—Their Life, Lore, and Environment*. B. P. Bishop Museum Bulletin 233.

HERON, C. L., R. P. EVERSLED, L. J. GOAD, AND V. DENHAM

- 1991 New approaches to the analysis of organic residues from archaeological remains, in *Archaeological Sciences 1989*: 332–339, ed. P. Budd, B. Chapman, R. Janaway, and B. Ottaway. Oxbow Monograph 9.

HILL, H. E. (TED)

- 1988 Progress on the chemical typing of selected Pacific cultigens. *Indo-Pacific Prehistory Association Bulletin* 8: 167–175.

HILL, H. E., J. EVANS, AND M. CARD

- 1985 Organic residues on 3000-year-old potsherds from Natunuku, Fiji. *New Zealand Journal of Archaeology* 7: 125–128.

- HOMMON, R. J.  
1976 The Formation of Primitive States in Pre-Contact Hawai'i. Ph.D. diss., University of Arizona, Tucson.  
1986 Social evolution in ancient Hawai'i, in *Island Societies: Archaeological Approaches to Evolution and Transformation*: 55-68, ed. P. V. Kirch. Cambridge: Cambridge University Press.
- HYLAND, D. C., J. M. TERSAK, J. M. ADOVASIO, AND M. I. SIEGEL  
1990 Identification of the species of origin of residual blood on lithic material. *American Antiquity* 55: 104-112.
- Ū, J. P.  
1959 *Fragments of Hawaiian History*, trans. M. K. Pukui, ed. D. Barrère. Honolulu: Bishop Museum Press.
- JACOMB, C.  
1990 A polished nephrite knife from Arthur's Pass, New Zealand. *Archaeology in New Zealand* 33: 164-168.
- KABAT, E. A., AND M. M. MEYER  
1967 *Experimental Immunochemistry*. Springfield, IL: Thomas.
- KAMAKAU, S. M.  
1976 *The Works of the People of Old*. B. P. Bishop Museum Special Publication 61. Honolulu: Bishop Museum Press.
- KAMMINGA, J.  
1979 The nature of use-polish and abrasive smoothing on stone tools, in *Lithic Use-Wear Analysis*: 143-158, ed. B. Hayden. New York: Academic Press.
- KIND, S. S., AND R. M. CLEEVELY  
1969 The use of ammoniacal bloodstain extracts in ABO groupings. *Journal of Forensic Sciences* 15: 131-134.
- KIRCH, P. V.  
1975 Excavations at Sites A1-3 and A1-4: Early settlement and ecology in Halawa Valley, in *Prehistory and Ecology in a Windward Hawaiian Valley: Halawa Valley, Moloka'i*: 17-70, ed. P. V. Kirch and M. Kelly. Pacific Anthropological Records 24. Honolulu: Bishop Museum.  
1979 *Marine Exploitation in Prehistoric Hawai'i: Archaeological Investigations at Kalāhuipua'a, Hawai'i Island*. Pacific Anthropological Records 29. Honolulu: Bishop Museum.  
1984 *The Evolution of the Polynesian Chiefdoms*. Cambridge: Cambridge University Press.  
1985 *Feathered Gods and Fishhooks*. Honolulu: University of Hawai'i Press.  
1989 The portable artifact assemblages, in *Prehistoric Hawaiian Occupation in the Anahulu Valley, O'ahu Island: Excavations in Three Inland Rockshelters*: 111-123, ed. P. V. Kirch. Contributions of the University of California Archaeological Research Facility 47, Berkeley.
- KOLB, M. J.  
1991 Social Power, Chiefly Authority, and Ceremonial Architecture, in an Island Polity, Maui, Hawaii. Ph.D. diss., University of California, Los Angeles.
- KOOSMAN, B., M. E. NEWMAN, AND H. CERI  
1992 Verifying the reliability of blood residue analysis on archaeological tools. *Journal of Archaeological Science* 19: 265-269.
- LEE, H. C., AND P. R. DEFOREST  
1976 A precipitin-inhibition test on denatured bloodstains for the determination of human origin. *Journal of Forensic Sciences* 21: 804-809.
- LOWENSTEIN, J. M.  
1981 Immunological reactions from fossil material. *Philosophical Transactions of the Royal Society of London* B292: 143-149.  
1985 Molecular approaches to the identification of species. *American Scientist* 72: 541-547.
- LOY, T. H.  
1983 Prehistoric blood residues: Detection on tool surfaces and identification of species of origin. *Science* 220: 1269-1271.  
1987 Recent advances in blood residue analysis, in *Archaeometry: Further Australasian Studies*: 57-65, ed. W. R. Ambrose and J. M. J. Mummery. Canberra: Australian National University.

- LOY, T. H., R. JONES, D. E. NELSON, B. MEEHAN, J. VOGEL, J. SOUTHON, AND R. COSGROVE  
1990 Accelerator radiocarbon dating of human blood proteins in pigments from Late Pleistocene art sites in Australia. *Antiquity* 64: 110–116.
- LOY, T. H., M. SPRIGGS, AND S. WICKLER  
1992 Direct evidence for human use of plants 28,000 years ago: Starch residues on stone artifacts from the Northern Solomon Islands. *Antiquity* 66: 898–912.
- LOY, T. H., AND A. R. WOOD  
1989 Blood residue analysis at Cayonu Tepesi, Turkey. *Journal of Field Archaeology* 16: 451–460.
- MACEY, H. L.  
1979 The identification of human blood in a 166-year-old stain. *Canadian Journal of Forensic Sciences* 12: 191–193.
- MALO, D.  
1951 *Hawaiian Antiquities (Mo'olelo Hawai'i)*. B. P. Bishop Museum Special Publication 2. Honolulu: Bishop Museum Press.
- MCALLISTER, J. G.  
1933 *Archaeology of Oahu*. B. P. Bishop Museum Bulletin 104. Honolulu: Bishop Museum Press.
- MORGAN, E. D., C. EDWARDS, AND S. A. PEPPER  
1992 Analysis of the fatty debris from the wreck of a Basque whaling ship at Red Bay, Labrador. *Archaeometry* 34: 129–133.
- MORGENSTEIN, M.  
1990 Hydration-rind dating of basaltic glass artifacts: Reaction dependence of temperature and chemistry. *Asian Perspectives* 27: 265–270.
- MORGENSTEIN, M., AND T. J. RILEY  
1975 Hydration-rind dating of basaltic glass: A new method for archaeological chronologies. *Asian Perspectives* 17: 145–159.
- NEAL, M. C.  
1965 *In Gardens of Hawai'i*. B. P. Bishop Museum Special Publication 50. Honolulu: Bishop Museum.
- NEWMAN, M. E.  
1990 The Hidden Evidence from Hidden Cave, Nevada. Ph.D. diss., University of Toronto.  
1992 Immunological analysis of artifacts from O'ahu and Hawai'i. Manuscript on file, Anthropology Department, Bishop Museum, Honolulu.
- NEWMAN, M. E., AND P. JULIG  
1989 The identification of protein residues on lithic artifacts from a stratified boreal forest site. *Canadian Journal of Archaeology* 13: 119–132.
- NEWMAN, M. E., R. M. YOHE, H. CERI, AND M. SUTTON  
1993 Immunological protein residue analysis of non-lithic archaeological materials. *Journal of Archaeological Science* 20: 93–102.
- OUDEMANS, T. F. M., AND J. J. BOON  
1991 Molecular archaeology: Analysis of charred (food) remains from prehistoric pottery by pyrolysis-gas chromatography/mass spectrometry. *Journal of Analytical and Applied Pyrolysis* 20: 197–227.
- PUKUI, M. K., AND S. H. ELBERT  
1986 *Hawaiian Dictionary*. Honolulu: University Press of Hawai'i.
- PUKUI, M. K., E. W. HAERTIG, AND C. A. LEE  
1972 *Nānā I ke Kumu (Look to the Source), Volume I*. Honolulu: Hui Hānai, Queen Liliuokalani Children's Center.
- REEVE, R.  
1983 Archaeological investigations in Section 3, in *Archaeological Investigations of the Mudlane-Waimea-Kawaihae Road Corridor, Island of Hawai'i*: 181–239, ed. J. T. Clark and P. V. Kirch. Department of Anthropology Report Series 83-1. Honolulu: Bishop Museum.



- RICHARDS, R.  
1990 On a surface collection of Western Samoan stone tools. *Archaeology in New Zealand* 33:132-151.
- RIFORD, M.  
1994 Artifacts of indigenous manufacture, in *Kula and Kahawai: Geoarchaeological and historical investigations in Middle Maunawili Valley, Kailua, Ko'olau Poko, O'ahu*, ed. J. Allen. Manuscript on file, Anthropology Department, Bishop Museum, Honolulu.
- ROBINSON, N., R. P. EVERSLED, W. J. HIGGS, K. JERMAN, AND G. EGLINTON  
1987 Proof of a pine wood origin for pitch from Tudor (Mary Rose) and Etruscan shipwrecks: Application of analytical organic chemistry in archaeology. *Analyst* 112:637-644.
- ROSENDAHL, P. H.  
1972 Aboriginal Agriculture and Residence Patterns in Upland Lapakahi, Island of Hawai'i. Ph.D. diss., University of Hawai'i, Honolulu.
- ROSENDAHL, P. H., R. COORAY, M. KELLY, P. V. KIRCH, P. C. MCCOY, AND A. SINOTO  
1976 *Archaeological Investigations in Upland Kaneohe*. Department of Anthropology Report Series 76-1. Honolulu: Bishop Museum.
- ROYAL CANADIAN MOUNTED POLICE  
1983 *Serological Methods Manual*. Ottawa: Royal Canadian Mounted Police, Serology Section.
- SCHICK, K. D., AND N. TOTH  
1993 *Making Silent Stones Speak*. New York: Simon and Schuster.
- SCHILT, R., ED.  
1984 *Subsistence and Conflict in Kona, Hawai'i: An Archaeological Study of the Kuakini Highway Realignment Corridor*. Department of Anthropology Report Series 84-1. Honolulu: Bishop Museum.
- SCHOUSBOE, R., M. F. RIFORD, AND P. V. KIRCH  
1983 Volcanic-glass flaked stone artifacts, in *Archaeological Investigations of the Mudlane-Waimea-Kawaihae Road Corridor, Island of Hawai'i*: 348-370, ed. J. T. Clark and P. V. Kirch. Department of Anthropology Report Series 83-1. Honolulu: Bishop Museum.
- SENSABAUGH, G. F., A. C. WILSON, AND P. L. KIRK  
1971 Protein stability in preserved biological remains. *International Journal of Biochemistry* 2: 545-568.
- SHAFFER, H. J., AND R. G. HOLLOWAY  
1979 Organic residue analysis in determining stone tool function, in *Lithic Use-Wear Analysis*: 385-399, ed. B. Hayden. New York: Academic Press.
- SMITH, P. R., AND M. T. WILSON  
1992 Blood residues on ancient tool surfaces: A cautionary note. *Journal of Archaeological Science* 19:237-241.
- TITCOMB, M.  
1969 *Dog and Man*. B. P. Bishop Museum Special Publication 59. Honolulu: Bishop Museum.
- WAGNER, W. L., D. R. HERBST, AND S. H. SOHMER  
1990 *Manual of the Flowering Plants of Hawai'i*. Honolulu: Bishop Museum Press.
- WALLS, J.  
1991 Quartzite and whales in Golden Bay. *Archaeology in New Zealand* 34:158-160.
- WILLIAMS, S. S.  
1991 Early upland settlement expansion and the effect of geomorphological change on the archaeological record in upland Kāne'ohe, O'ahu. Paper presented at the 17th Pacific Science Congress, Honolulu, May 27-June 2.
- YOHE, R. M., M. E. NEWMAN, AND J. S. SCHNEIDER  
1991 Immunological identification of small-mammal proteins on aboriginal milling equipment. *American Antiquity* 56:659-666.

## ABSTRACT

Stone tools recovered from Bishop Museum Sites 50-Oa-G5-97 and G5-152 in upland Kāne'ohe, O'ahu, have produced the first animal and plant residue identifi-

cations reported for sites in the Hawaiian Islands. After microscopic inspection for signs of edge wear, 20 tools were analyzed through cross-over electrophoresis; five tested positive against anti-dog, anti-pig, and anti-fern sera. Historical information concerning pre-Contact (pre-A.D. 1778) Hawaiian uses of dog, pig, and fern is summarized, and the technique and current results are evaluated in terms of the information they promise concerning artifact and site function, dating, intersite networks, and sociopolitical developments. KEYWORDS: artifact function, cross-over electrophoresis (CIEP), Hawaiian archaeology, lithics, residue analysis, use wear.